# Impact of Surrounding Water Table Dynamics on a Forested Wetland Ecosystem in Northern Nigeria: A Case Study of the Hadejia-Nguru Wetlands

**Mohammed Lawal Nuruddeen1* and Dr Paritosh Srivastava[2]**

1*Department of Civil Engineering, School of Engineering and Technology, Noida International University-NIU, Gautam Budh Nagar, 201308.
Email: mlnuruddeen@gmail.com, ORCID ID: 0000-0003-4941-0185)
[2] Centre of Excellence: Occupational Health, Safety, Fire & Environment.G. D. Goenka University, Gurugram
Email: paritosh.srivastava@gdgu.org, ORCID ID: 0009-0000-7684-286X)
*Corresponding Author: Mohammed Lawal Nuruddeen, Email: mlnuruddeen@gmail.com

**Abstract**
Nigeria is endowed with extensive wetlands that are vital for ecological stability, biodiversity, and local livelihoods. This study focuses on the Hadejia-Nguru Wetlands, a critical floodplain ecosystem in Northern Nigeria, to evaluate the impact of water table dynamics on wetland ecology and community livelihoods. Employing an observational study design, data were collected through structured questionnaires, environmental temperature and humidity measurements, and statistical analysis using SPSS.
The study revealed that respondents, predominantly males aged 30–39 years with primary or Islamic education, relied heavily on the wetlands for farming (67.5%), animal rearing (22.0%), and fishing (9.5%). Seasonal and annual fluctuations in the water table were frequently observed, with human activities (34.0%) and natural factors (31.4%) being the primary drivers. Significant ecological impacts included the loss of plant species (63.7%) and reduced fish availability (22.8%). Conservation efforts, primarily reforestation (72.4%), controlled farming practices (21.6%), and awareness campaigns (6.0%), were acknowledged by the community as strategies to mitigate wetland degradation.
The findings underscore the critical role of water table management in sustaining the ecological and socio-economic functions of the Hadejia-Nguru Wetlands. Effective conservation strategies and sustainable water resource management practices are essential to safeguard this vital ecosystem and the livelihoods it supports.
Keywords: Community, Ecosystem, Hadejia-Nguru, Water table, Wetland,

## Introduction

Nigeria is home to a substantial network of wetlands, encompassing approximately 2,988,000 hectares of land designated as wetland areas (Olalekan et al., 2014). This vast wetland region includes different types, such as freshwater swamps covering about 2,130,000 hectares and mangrove areas spanning 858,000 hectares (Husain and Sharma, 2022). These wetlands play vital ecological roles, serving as habitats for diverse species, regulating water quality and flow, supporting agriculture and fishing, and contributing significantly to environmental stability.

In Northern Nigeria, particularly in semi-arid regions, water scarcity is a major challenge, influencing the ecosystems' ability to sustain themselves (Ayanlade et al., 2022). Forested wetlands, such as those in the Hadejia-Nguru Wetlands, are especially sensitive to fluctuations in the water table, which are driven by both natural factors, like unpredictable rainfall patterns, and human activities, such as agricultural practices and groundwater extraction (Ballut-Dajud et al., 2022).

The Hadejia-Nguru Wetlands, located in Northwestern Nigeria, are expansive floodplains formed by the convergence of the Hadejia and Jama'are rivers, which drain into Lake Chad via the Komodugu-Yobe River (Olalekan et al., 2014). The wetlands cover approximately 350,000 hectares and lie at an altitude ranging between 152 and 305 meters above sea level (Birdlife International, 2015). The area's climate features two distinct seasons: a wet season from May to September and a dry season from October to April, with annual rainfall ranging between 500-600 mm. Temperatures vary significantly, with lows of 12°C during the Harmattan season and highs of 40°C during the hot season, typically between December and April (Dan'azumi and Ibrahim, 2023).

The water table, which lies between the unsaturated topsoil and the saturated zone beneath, is a dynamic layer that fluctuates in both thickness and depth. It is influenced by factors such as precipitation patterns, underlying geological formations, and human activities like groundwater extraction and agriculture (Joly, 2021). The water table plays an important role in the structural integrity of properties, especially buildings with basements. High water tables can lead to foundation issues, such as cracks and leaks, posing risks to the stability of structures (Olurotimi et al., 2023). To prevent such damage, waterproofing measures are essential to safeguard foundations from the adverse effects of rising water tables (Chew, 2021). Conversely, if the water table is too low, foundations may lack sufficient support, leading to fractures or collapse.

The study aimed to assess the impact of surrounding water table dynamics on the forested wetland ecosystem of the Hadejia-Nguru Wetlands. Specifically, it seeks to understand how fluctuations in the water table, influenced by natural and anthropogenic factors, affect the wetland's ecological functions and the livelihoods of local communities.

## Methodology

### Study Design

An observational design was used to assess the relationship between water table dynamics and wetland ecology.

### Study Area

The study was conducted in Hadejia-Nguru wetland situated in Northern Nigeria. The wetland supports significant biodiversity and sustains local communities through agriculture, fishing, and grazing. However, the region is vulnerable to water table alterations caused by seasonal variations, irrigation, and climate change. The site was chosen based on accessibility, biodiversity richness, and evidence of water table variability.

### Data Collection

A pre-tested, open-ended structured questionnaire was used to collect data form the local community members to understand traditional knowledge, resource use, and perceived impacts of water table changes. A total of 400 questionnaires were distributed to participants using convenience sampling techniques. Of these, 391 were successfully retrieved and included in the analysis.

### Environmental Temperature and Humidity Measurement

**Temperature Measurement**

Environmental temperature was recorded using a mercury thermometer. To ensure accuracy, the thermometer was placed in a shaded area, away from direct sunlight, to prevent heat interference from solar radiation. Measurements were taken at consistent intervals to account for temporal variations.

**Humidity Measurement**

Relative humidity was measured using hygrometers. The devices were calibrated prior to use to maintain precision. Measurements were conducted in the same location as the temperature readings to provide a comprehensive assessment of the local environmental conditions.

**Data Analysis**

The data generated was analysed using the Statistical Package for Social Sciences (SPSS) for windows version 25.0 used for statistical analysis and data interpretation using simple descriptive statistics.

**RESULT**

Participants aged 30–39 years constituted the largest age group, with 117 (29.9%) respondents, followed by 102 (26.1%) aged ≥60 years and 94 (24.0%) aged 50–59 years. Male participants, 290 (74.2%), predominated over their female counterparts, 101 (25.8%). In terms of education, most participants had primary education (142, 36.3%), followed by Islamic education (101, 25.8%). Regarding occupations, 166 (42.5%) were farmers, 86 (22.0%) were herders, and 63 (16.1%) were civil servants. Additionally, 133 (34.0%) of the respondents reported residing in the area for over 10 years (Table 1).

The study site had an average mean temperature of 30.62 ± 1.79°C and an average relative humidity of 55.51 ± 3.95% (Table 2). A significant proportion of respondents, 331 (84.7%), were aware of the importance of wetlands in their community, while 20 (5.1%) were unaware, and 40 (10.2%) were uncertain. Among respondents, 50.4% recognized wetlands as essential for farming activities, 32.0% appreciated their ecological role as habitats for plants and animals, and 17.6% considered them a source of water.

The primary activity associated with wetlands was farming, reported by 264 (67.5%) respondents, followed by animal rearing (86, 22.0%) and fishing (37, 9.5%). Over half of the respondents, 212 (54.2%), reported a decrease in wetland usage over time, while 141 (36.1%) noted stability in usage (Table 3).

A majority of respondents, 303 (77.5%), observed changes in water levels over time, with seasonal variations being the most commonly reported (214, 70.6%), followed by annual variations (80, 26.4%). Regarding perceptions of water table changes, 104 (34.0%) attributed these changes primarily to human activities, 95 (31.4%) to natural factors, and 81 (26.7%) to a combination of both. The most significant impact of water table changes was the loss of plant species, reported by 193 (63.7%) respondents, followed by reduced fish availability (69, 22.8%) and reduced crop yield (41, 13.5%). More than half of the respondents, 232 (59.3%), acknowledged efforts to protect wetlands. Among these, 72.4% highlighted reforestation as the major conservation effort, 21.6% cited controlled farming practices, and 6.0% mentioned awareness campaigns as significant measures to safeguard wetlands and stabilize water tables in the area (Table 4).

**Table 1 Distribution of the Demographic Variable among the Study Participants**

| Demographic Variables | Frequency | Percentages |
|---|---|---|

| | | |
|---|---|---|
| **Age (Years)** | | |
| <20 | 22 | 5.6 |
| 20 – 29 | 23 | 5.9 |
| 30 – 39 | 117 | 29.9 |
| 40 – 49 | 33 | 8.4 |
| 50 – 59 | 94 | 24.0 |
| ≥60 | 102 | 26.1 |
| Total | 391 | 100.0 |
| **Sex** | | |
| Male | 290 | 74.2 |
| Female | 101 | 25.8 |
| Total | 391 | 100.0 |
| **Education** | | |
| Islamic | 101 | 25.8 |
| Primary | 142 | 36.3 |
| Secondary | 80 | 20.5 |
| Tertiary | 68 | 17.4 |
| Total | 391 | 100.0 |
| **Occupation** | | |
| Civil Servant | 63 | 16.1 |
| Farmer | 166 | 42.5 |
| Fisherman | 37 | 9.5 |
| Herders | 86 | 22.0 |
| Hunter | 18 | 4.6 |
| Trade | 21 | 5.4 |
| Total | 391 | 100.0 |
| How long do lived in this region (Years) | | |
| <1 | 22 | 5.6 |
| 1 – 2 | 33 | 8.4 |
| 3 – 4 | 76 | 19.4 |
| 5 – 6 | 37 | 9.5 |
| 7 – 8 | 68 | 17.4 |
| 9 – 10 | 22 | 5.6 |
| >10 | 133 | 34.0 |
| Total | 391 | 100.0 |

**Table 2 Climate Conditions of the Hadejia-Nguru Wetlands**

| Variables | Mean | STD | Minimum | Maximum |
|---|---|---|---|---|
| Temperature ($^{o}$C) | 30.62 | 1.79 | 23.00 | 33.10 |
| Humidity (%) | 55.51 | 3.95 | 49.00 | 64.00 |

**Table 3 Knowledge of Wetland Ecosystems and Resource Use and Activities**

| | Frequency | Percentages |
|---|---|---|
| **Are you aware of the wetlands important in your community?** | | |

| | | |
|---|---|---|
| Yes | 331 | 84.7 |
| No | 20 | 5.1 |
| Don't Know | 40 | 10.2 |
| **How do you perceive the importance of wetlands?** | | |
| Source of water | 69 | 17.6 |
| Habitat for plants and animals | 125 | 32.0 |
| Support for agriculture | 197 | 50.4 |
| Other (specify): | | |
| **Do you depend on the wetland for any of the following?** | | |
| Farming | 264 | 67.5 |
| Fishing | 37 | 9.5 |
| Animal Rearing | 86 | 22.0 |
| Firewood collection | 4 | 1.0 |
| Water for domestic use | 0 | 0.0 |
| Other (specify) | 0 | 0.0 |
| **How has your use of the wetland changed over the years?** | | |
| Increased | 38 | 9.7 |
| Decreased | 212 | 54.2 |
| Remained the same | 141 | 36.1 |

**Table 4 Perception of Water Table Fluctuations and Impact of Water Table Changes**

| | Frequency | Percentages |
|---|---|---|
| **Have you observed changes in water levels in the wetland over time?** | | |
| Yes | 303 | 77.5 |
| No | 88 | 22.5 |
| **If yes, how often do these changes occur?** | | |
| Seasonally | 214 | 70.6 |
| Annually | 80 | 26.4 |
| Other (specify) | 9 | 3.0 |
| **What do you think causes these changes?** | | |
| Natural factors (e.g., rainfall patterns) | 95 | 31.4 |
| Human activities (e.g., farming, deforestation) | 103 | 34.0 |
| Both | 81 | 26.7 |
| Don't know | 24 | 7.9 |
| **What impacts have you noticed due to changes in water levels? (Select all that apply)** | | |
| Reduced crop yield | 41 | 13.5 |
| Loss of plant species | 193 | 63.7 |
| Reduced fish availability | 69 | 22.8 |
| Other (specify) | 0 | 0.0 |
| **How have these impacts affected your livelihood?** | | |

| | | |
|---|---|---|
| Slightly | 63 | 20.8 |
| Moderately | 58 | 19.1 |
| Significantly | 182 | 60.1 |
| **Are there any efforts in your community to protect the wetland?** | | |
| Yes | 232 | 59.3 |
| No | 123 | 31.5 |
| Don't Know | 36 | 9.2 |
| **If yes, what actions are being taken?** | | |
| Reforestation | 168 | 72.4 |
| Controlled farming practices | 50 | 21.6 |
| Awareness campaigns | 14 | 6.0 |
| Other (specific) | 0 | 0.0 |

Discussion:

The climate conditions of an environment are essential tools that provide valuable insights into the environmental factors and influence the region (Bramer et al., 2018). The report of the climate conditions of the Hadejia-Nguru Wetlands was recorded as characterized by warm temperatures and moderate humidity, which create a stable environment that can support agriculture, biodiversity, and human activities in the area. The result of the present study agreed with what was recorded by Ringim et al. (2015), Dami et al. (2017) and Gujja et al. (2023) all recorded a temperature range between 22.32C to 38.17C.

A significant majority (84.7%) of respondents are aware of the importance of wetlands in their community, indicating a high level of environmental awareness. This finding aligns with studies highlighting that communities residing near wetlands often recognize their ecological and economic significance (Bukar et al., 2021; Gujja et al., 2023).

The most common perception (50.4%) is that wetlands primarily support agriculture, followed by their role as habitats for plants and animals (32.0%) and as a source of water (17.6%). These findings emphasize the direct economic benefits of wetlands, particularly for farming, which is consistent with observations by Usman (2024) and Bukar et al. (2021).

Farming (67.5%) is the predominant activity associated with wetland use, followed by animal rearing (22.0%) and fishing (9.5%). Firewood collection (1.0%) and water for domestic use (0%) have minimal representation. This reliance on wetlands for agriculture reflects their critical role in food security, a pattern commonly observed in developing regions. These findings corroborate the reports by Jajere et al. (2023a), Jajere et al. (2023b), and Bukar et al. (2021), which highlighted that communities depend directly or indirectly on wetlands for their livelihoods.

Over half of the respondents (54.2%) reported a decrease in wetland use over the years, while 36.1% observed no change, and only 9.7% reported increased use. The decline in wetland use could be attributed to factors such as wetland degradation, the implementation of stricter conservation policies, or shifts in livelihood practices. Similar trends have been documented in other studies, where overexploitation, environmental degradation, and climate change have resulted in reduced wetland functionality and productivity (Usman, 2024; Gujja et al., 2023; Jajere et al., 2023a; Bukar et al., 2021).

A majority (77.5%) of respondents have observed changes in water levels in the wetlands over time, highlighting significant awareness of water table fluctuations within the community.

Seasonal variations (70.6%) are the most frequently reported occurrences, followed by annual changes (26.4%). This pattern aligns with studies that attribute seasonal fluctuations in wetland water tables to climate variability and precipitation cycles (Bukar et al., 2021; Gujja et al., 2023). When asked about the causes of these changes, respondents predominantly pointed to human activities (34.0%), followed closely by natural factors such as rainfall patterns (31.4%), and a combination of both (26.7%). Similar findings have been reported by Usman (2024) and Jajere et al. (2023a), who identified agriculture, deforestation, and erratic rainfall as primary drivers of wetland water level changes in comparable regions. The remaining 7.9% of respondents expressed uncertainty, which suggests gaps in knowledge or awareness about ecological dynamics.

The impacts of water table changes on the wetlands have been significant. Loss of plant species (63.7%) emerged as the most frequently observed consequence, followed by reduced fish availability (22.8%) and reduced crop yield (13.5%). These findings are consistent with prior research showing that fluctuating water levels adversely affect wetland biodiversity, agricultural productivity, and fisheries (Bukar et al., 2021; Jajere et al., 2023b). The effects on livelihoods are also notable: 60.1% of respondents reported significant impacts, underlining the critical role of stable water tables for economic and subsistence activities. Moderate (19.1%) and slight (20.8%) impacts were less common, possibly reflecting varying degrees of dependency on wetland resources.

Efforts to protect the wetlands are acknowledged by 59.3% of respondents, indicating proactive community engagement in conservation activities. Reforestation (72.4%) is the most common intervention, followed by controlled farming practices (21.6%) and awareness campaigns (6.0%). These approaches mirror strategies recommended in other studies, which emphasize the importance of afforestation, sustainable land-use practices, and environmental education in mitigating wetland degradation (Gujja et al., 2023; Usman, 2024). However, 31.5% of respondents reported no conservation efforts, and 9.2% were unaware of such initiatives, signalling a need for broader community participation and improved outreach.

On exploring the participants' perceptions regarding the influence of strata characteristics on wetland water tables, and how these characteristics affect groundwater recharge and discharge systems. While many participants are familiar with the water table concept and the role of wetlands, still there are significant knowledge gaps regarding the specifics of soil and rock layers, and the influence of strata characteristics on the water table. Many participants largely recognize the influence of human activities and seasonal variations on the water table. However, there are fewer consensuses on the impact of natural events and the effectiveness of groundwater recharge methods.

**Conclusion**

The study highlights the significant impact of fluctuating water tables on the Hadejia-Nguru Wetlands in Northern Nigeria. These fluctuations, driven by natural factors (like rainfall patterns) and human activities (such as farming and deforestation), affect the wetland’s ecological health and the livelihoods of local communities. The resulting changes include reduced crop yields, loss of plant species, and diminished fish availability. While there are local conservation efforts such as reforestation and controlled farming, more coordinated actions are needed for effective wetland preservation.

**Recommendations**

Bases on the outcome of this study it was recommend

1. Implement integrated water management strategies, promoting efficient water use and rainwater harvesting.
2. Encourage sustainable farming practices to reduce environmental impact.
3. Involve local communities in conservation efforts through awareness campaigns and monitoring programs.
4. Enforce policies that regulate land use and water extraction to protect the wetland ecosystem.

**References**

Ayanlade, A., Oladimeji, A. A., Okegbola, O. M., Eludoyin, A. O., Eslamian, S., Ayinde, A. F., and Perkins, P. E. (2022). Effect of climate change on water availability and quality: an assessment of socio-resilience in Nigeria. In *Disaster Risk Reduction for Resilience: Disaster and Social Aspects* (pp. 245-262). Cham: Springer International Publishing.

Ballut-Dajud, G. A., Sandoval Herazo, L. C., Fernández-Lambert, G., Marín-Muñiz, J. L., López Méndez, M. C., and Betanzo-Torres, E. A. (2022). Factors affecting wetland loss: A review. *Land*, *11*(3), 434.

Bramer, I., Anderson, B. J., Bennie, J., Bladon, A. J., De Frenne, P., Hemming, D., ... and Gillingham, P. K. (2018). Advances in monitoring and modelling climate at ecologically relevant scales. In *Advances in ecological research* (Vol. 58, pp. 101-161). Academic Press.

Bukar, Y., Monguno, A. K., and AbdulRahman, A. T. (2021). Environmental Change and Livelihood Activities in Hadejia-Nguru Wetlands of Yobe State, North East Nigeria. *Journal of Geography and Geology*, *12*(3), 1-12.

Chew, M. Y. L. (2021). Design for maintainability of basements and wet areas. *Buildings*, *11*(2), 75.

Dami, A., Inuwa Kuchali, B., and Ayuba, H. K. (2017). The Influence of Climate Variability on Hadejia-Nguru Wetlands, Yobe State, Nigeria. *International Journal of Geography and Geology*, *6*(5), 105-112.

Dan'azumi, S., and Ibrahim, U. A. (2023). Trend analysis of observed precipitation, temperature, and streamflow for Hadejia-Nguru wetlands catchment, Nigeria. *Theoretical and Applied Climatology*, *151*(1), 195-207.

Gujja, A, A., Alkali, U, U., Nasuru, Y. (2023). Assessment of changes in climatic variables in hadeja-nguru wetlands. World J Forest Res, 2(1), 69-78.

Husain, S., and Sharma, V. P. (2022). Sustainable Crop Production in the Floodplains of Niger Delta, Nigeria. Book Chapter Crop production in the floodplain 2022, 196-219

Jajere, A. A., Nabegu, A. B., Bibi, U. M., Kibon, A. U., & Ismail, M. (2023a). Analysis of Hadeja-Nguru Wetlands Vegetation and Surface water response to rainfall variability Analysis of Hadeja-Nguru Wetlands Vegetation and Surface water response to rainfall variability.

Jajere, A. A., Saidu, A. M., Adamu, U., & Ibrahim, U. (2023b). Nexus between weeds secondary succession and livelihoods in Hadejia-Nguru wetlands of Nigeria. *Sustinere: Journal of Environment and Sustainability*, *7*(1), 48-64.

Joly, F. (2021). Water Falling onto Soil and the Effects It Produces. *Mankind and Deserts 2: Water and Salts*, 1-38.

Olalekan, E. I., Abimbola, L. M., Saheed, M., and Damilola, O. A. (2014). Wetland resources of Nigeria: case study of the Hadejia-Nguru wetlands. Poult Fish Wildl Sci 2: 123.

Olurotimi, O. J., Yetunde, O. H., and Akah, A. R. C. U. (2023). Assessment of the Determinants of Wall Cracks in Buildings: Investigating the Consequences and Remedial Measure for Resilience and Sustainable Development. *Int. J. Adv. Educ. Manag. Sci. Technol*, *6*, 121-132.

Ringim, A. S., Abubakar, M. M., Mohammed, S. I., and Shuaibu, T. U. (2015). Wetlands resource use, conflict, management and conservation: review of the Hadejia-Nguru wetlands, northeast, Nigeria. *International Journal of Innovative Science, Engineering and Technology*, *2*(10), 507-516.

Usman, A. U. (2024). Assessment of Livelihood Sustenance and Non-Timber Forest Product Availability of Hadeja-Nguru Wetlands Inhabitants. *International Journal of Agricultural and Veterinary Science*.